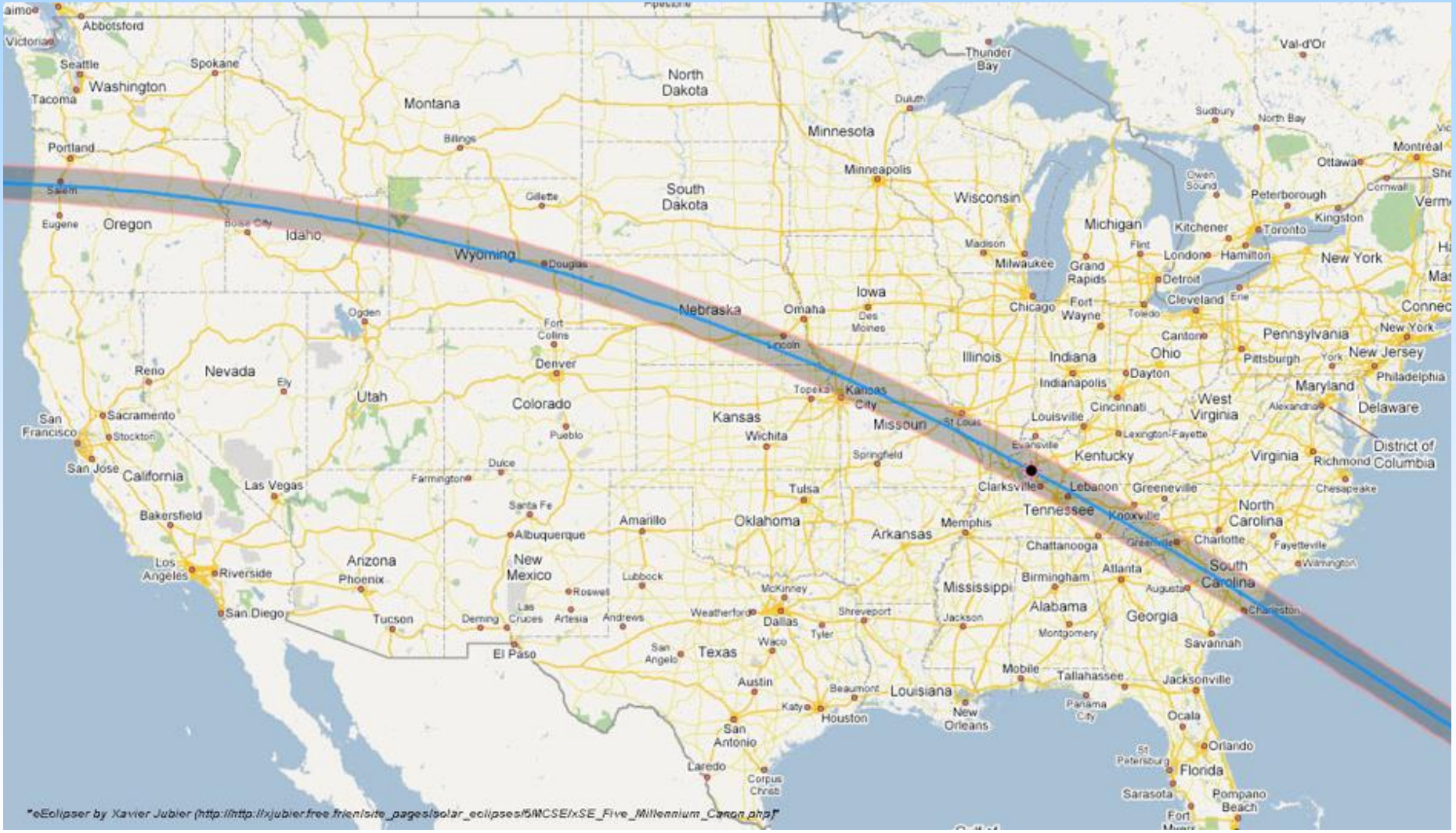
Solar Eclipses: Front Line Experiences, and Some Science

Dr. Alphonse Sterling
NASA/MSFC

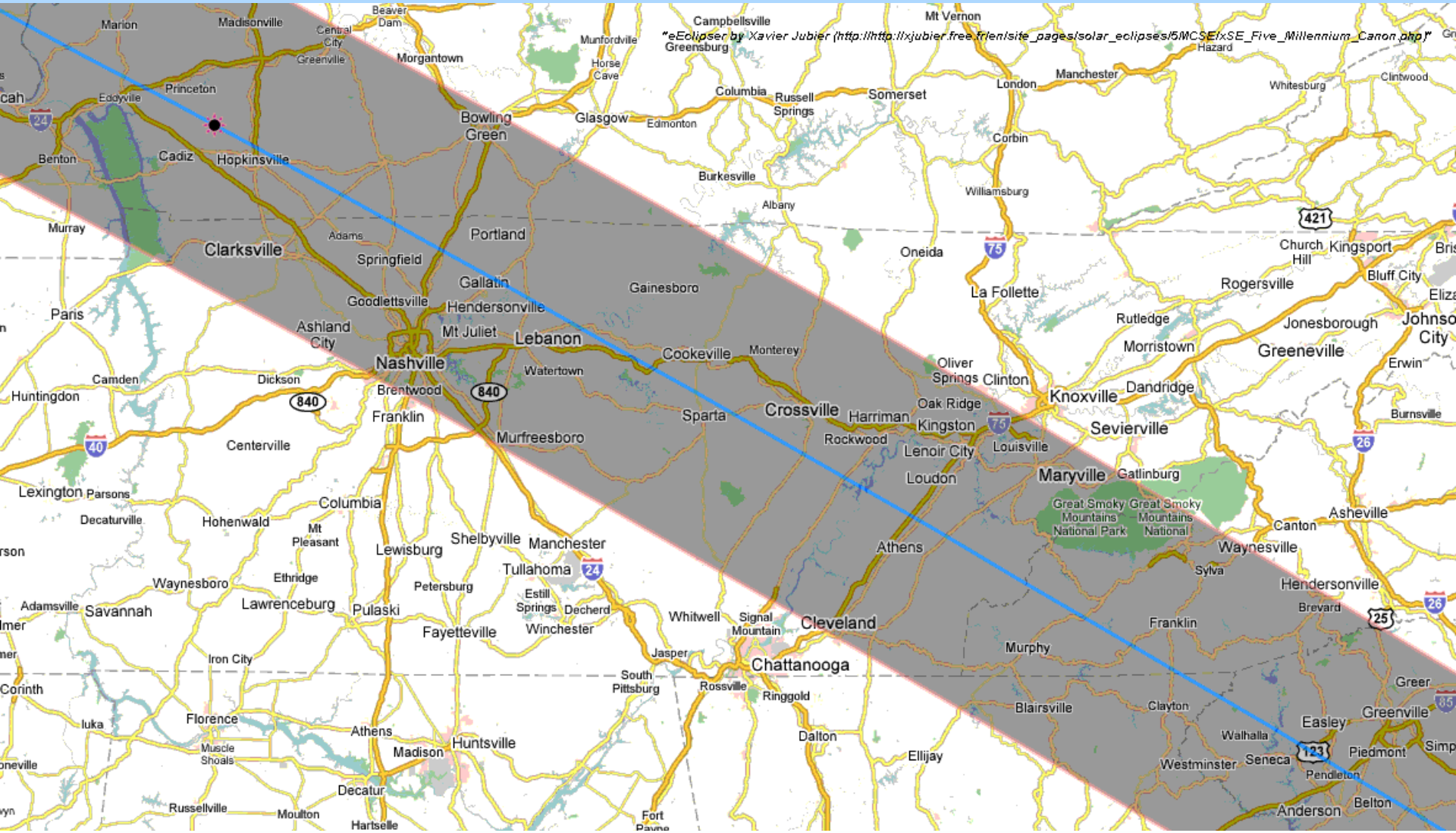
Today's Discussion:

- A brief review of the 21 August 2017 eclipse.
- A couple of experiences from the "front line" of past eclipses.
- The motivation for doing solar eclipse studies (just an outline…).

August 21, 2017 Total Solar Eclipse Path



August 21, 2017 Total Solar Eclipse Path


"eEclipser by Xavier Jubier (http://http://xjubier.free.fr/en/site_pages/solar_eclipses/5MCSEIxSE_Five_Millennium_Canon.php)"
Nashville
Clarksville
Bowling Green
Hopkinsville
Murfreesboro
Lebanon
Gallatin
Hendersonville
Springfield
Portland
Franklin
Brentwood
Columbia
Lewisburg
Shelbyville
Manchester
Tullahoma
Cookeville
Crossville
Sparta
Knoxville
Sevierville
Maryville
Gatlinburg
Oak Ridge
Kingston
Rockwood
Harriman
Clinton
Oliver Springs
Lenoir City
Loudon
Athens
Cleveland
Chattanooga
Dalton
Ringgold
Rossville
Jasper
Whitwell
Signal Mountain
Murphy
Blairsville
Clayton
Franklin
Sylva
Waynesville
Canton
Asheville
Hendersonville
Brevard
Greenville
Easley
Greer
Piedmont
Seneca
Westminster
Walhalla
Anderson
Belton
Pendleton
Ellijay
Fort Payne
Huntsville
Madison
Athens
Decatur
Florence
Muscle Shoals
Russellville
Moulton
Hartselle
Iuka
Corinth
Iron City
Pulaski
Fayetteville
Lawrenceburg
Savannah
Adamsville
Waynesboro
Ethridge
Mt Pleasant
Hohenwald
Decaturville
Lexington
Parsons
Centerville
Huntingdon
Camden
Dickson
Ashland City
Mt Juliet
Goodlettsville
Gallatin
Paris
Murray
Benton
Cadiz
Eddyville
Princeton
Marion
Madisonville
Central City
Greenville
Beaver Dam
Morgantown
Munfordville
Horse Cave
Glasgow
Edmonton
Albany
Burkesville
Columbia
Russell Springs
Somerset
Campbellsville
Greensburg
Mt Vernon
London
Corbin
Williamsburg
Manchester
Hazard
Whitesburg
Clintwood
Oneida
La Follette
Rogersville
Rutledge
Morristown
Jonesborough
Greeneville
Erwin
Johnson City
Bluff City
Church Hill
Kingsport
Burnsville
Great Smoky Mountains National Park
Great Smoky Mountains National
Canton
Waynesville
Sylva
Hendersonville
Brevard
Greenville
Easley
Greer
Piedmont
Seneca
Westminster
Walhalla
Anderson
Belton
Pendleton
Ellijay
Dalton
Blairsville
Clayton
Murphy
Franklin
Cleveland
Chattanooga
Ringgold
Rossville
Jasper
Whitwell
Signal Mountain
Tullahoma
Manchester
Shelbyville
Lewisburg
Columbia
Mt Pleasant
Hohenwald
Decaturville
Lexington
Parsons
Centerville
Huntingdon
Camden
Dickson
Ashland City
Mt Juliet
Goodlettsville

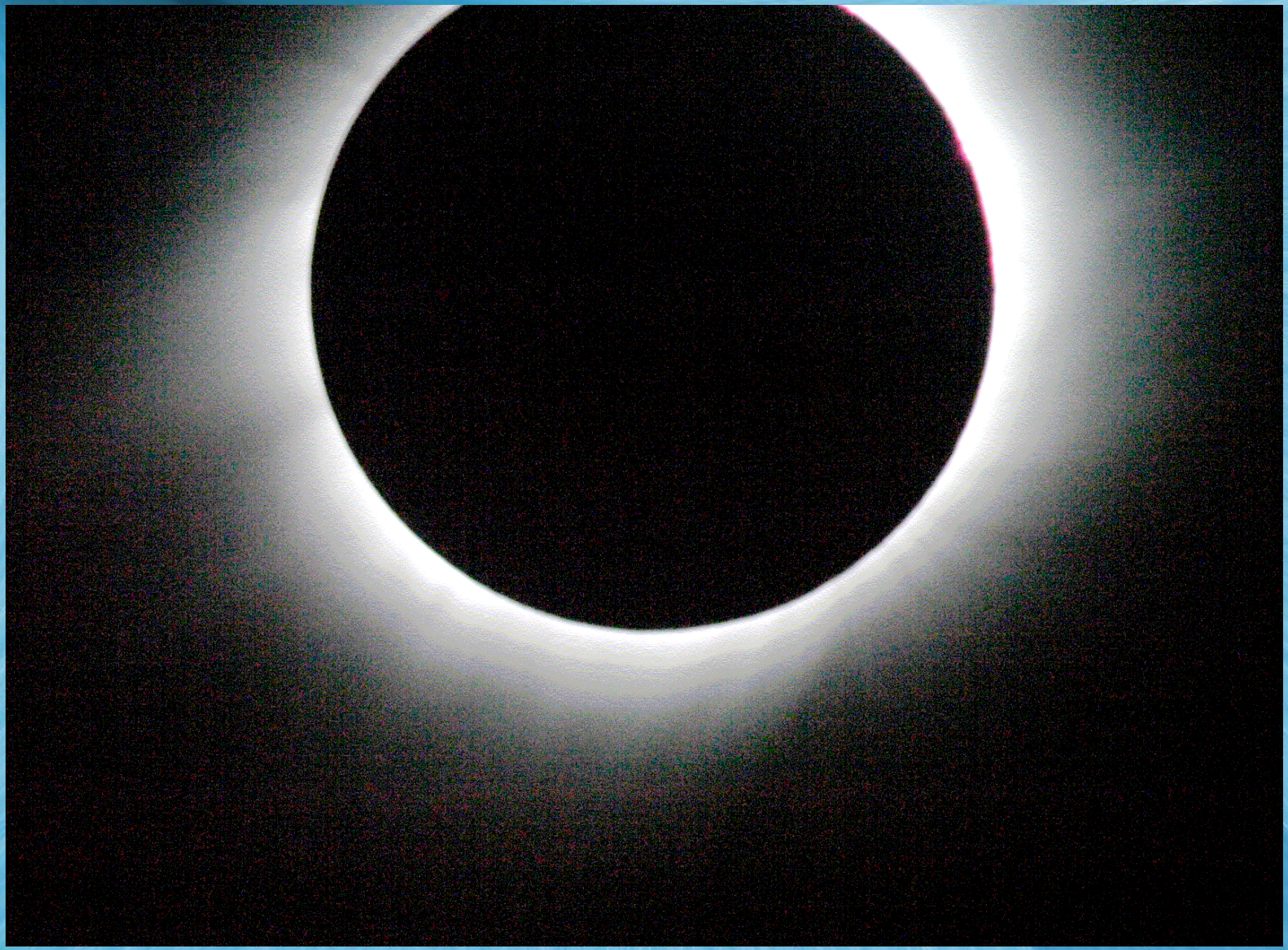
Do not Risk Your Precious Eyes!!

- Do ***not*** look at the partial phases of the eclipse directly without certified eye protection!!
- There's no point to staring at partial phases….

- Look without protection only if you're in the totality path, and then only during totality! (About 2 minutes.)

How *Not* to do Eclipse Science! Ghana 2006 Version

(Useful information for picture takers too.)

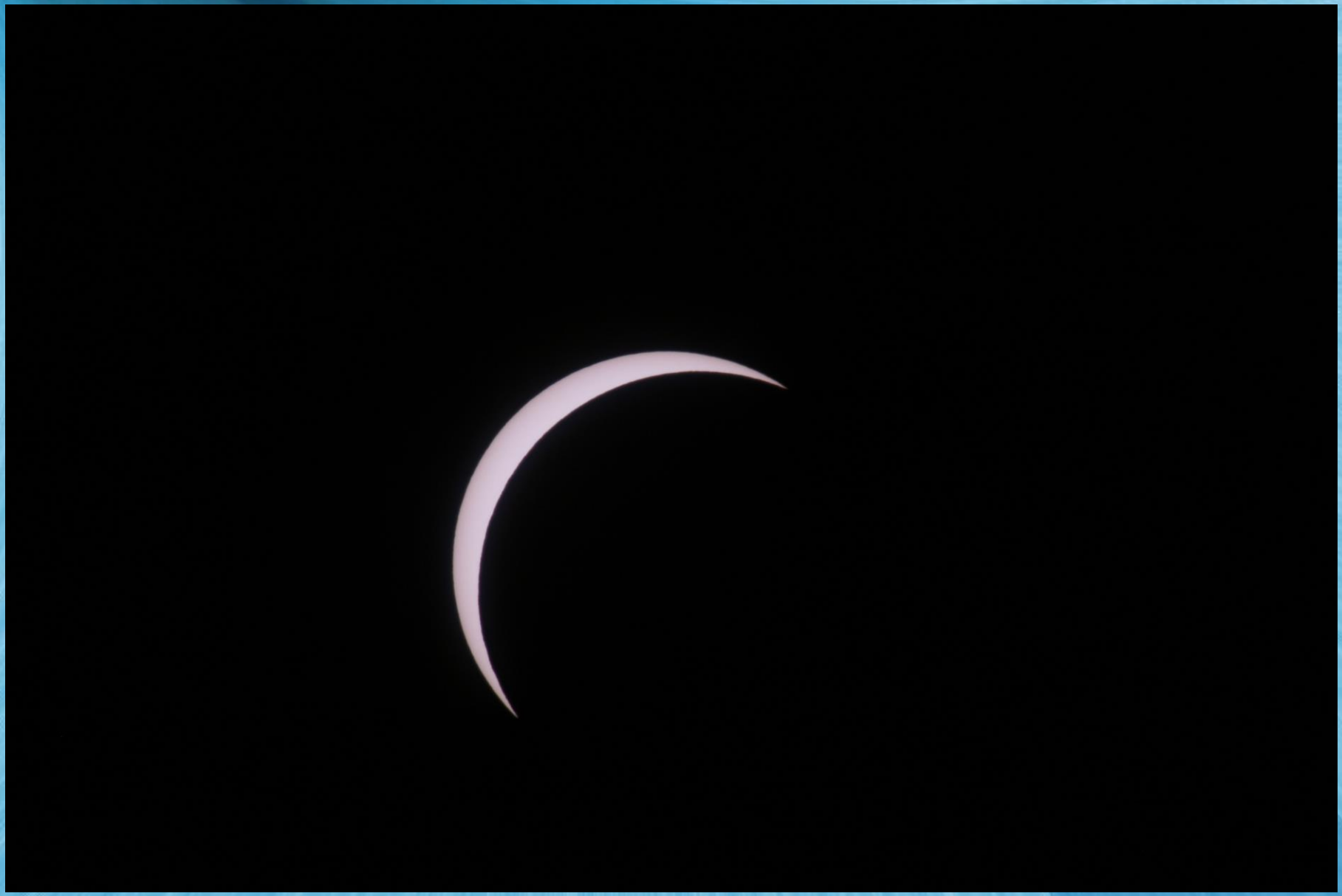


Lessons Learned (Science at Eclipses)

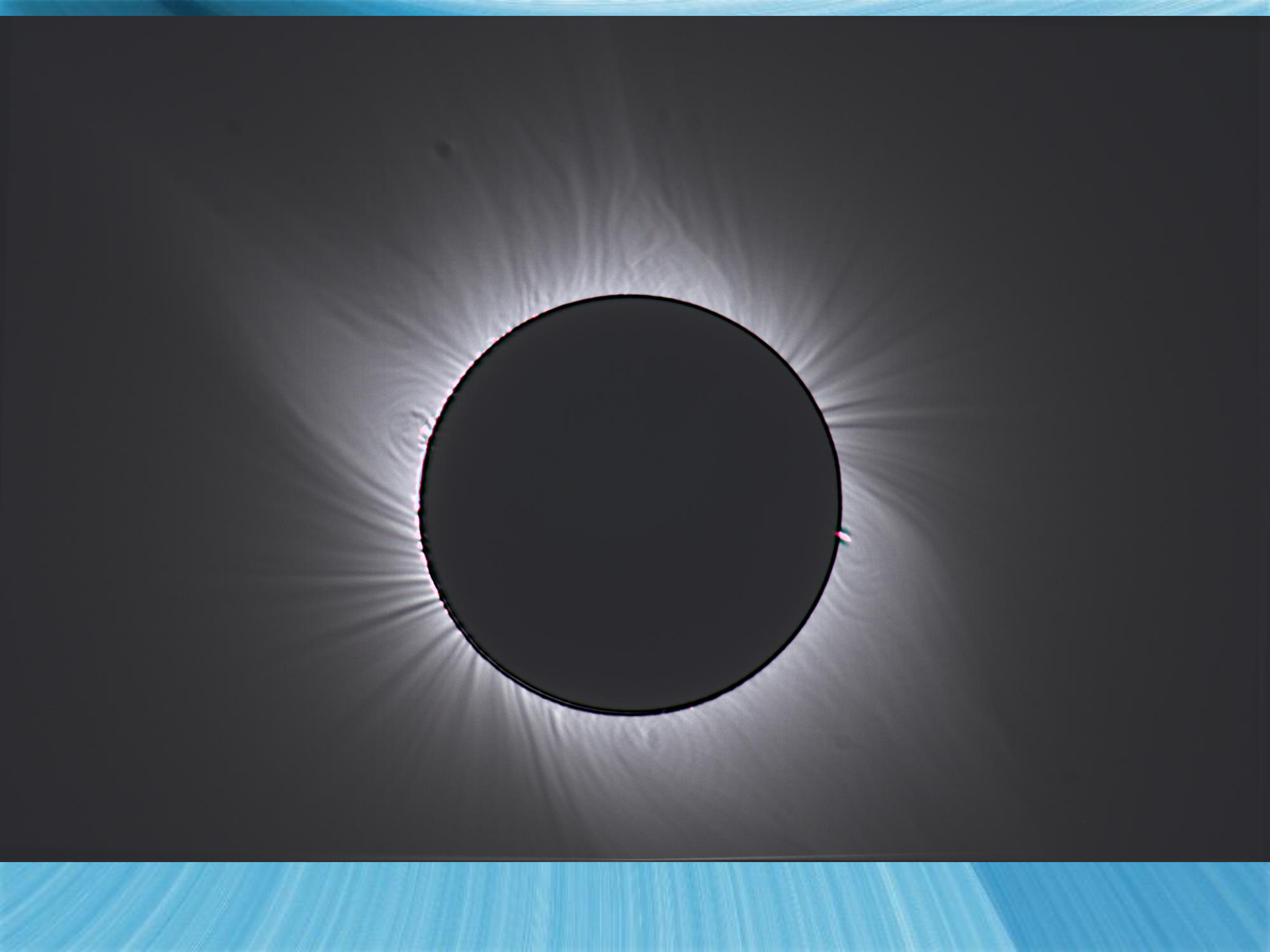
- No new equipment.
- Settle on a location, and stick to it if at all possible.
- Practice, practice, practice!

Gansu Province, China, 2008

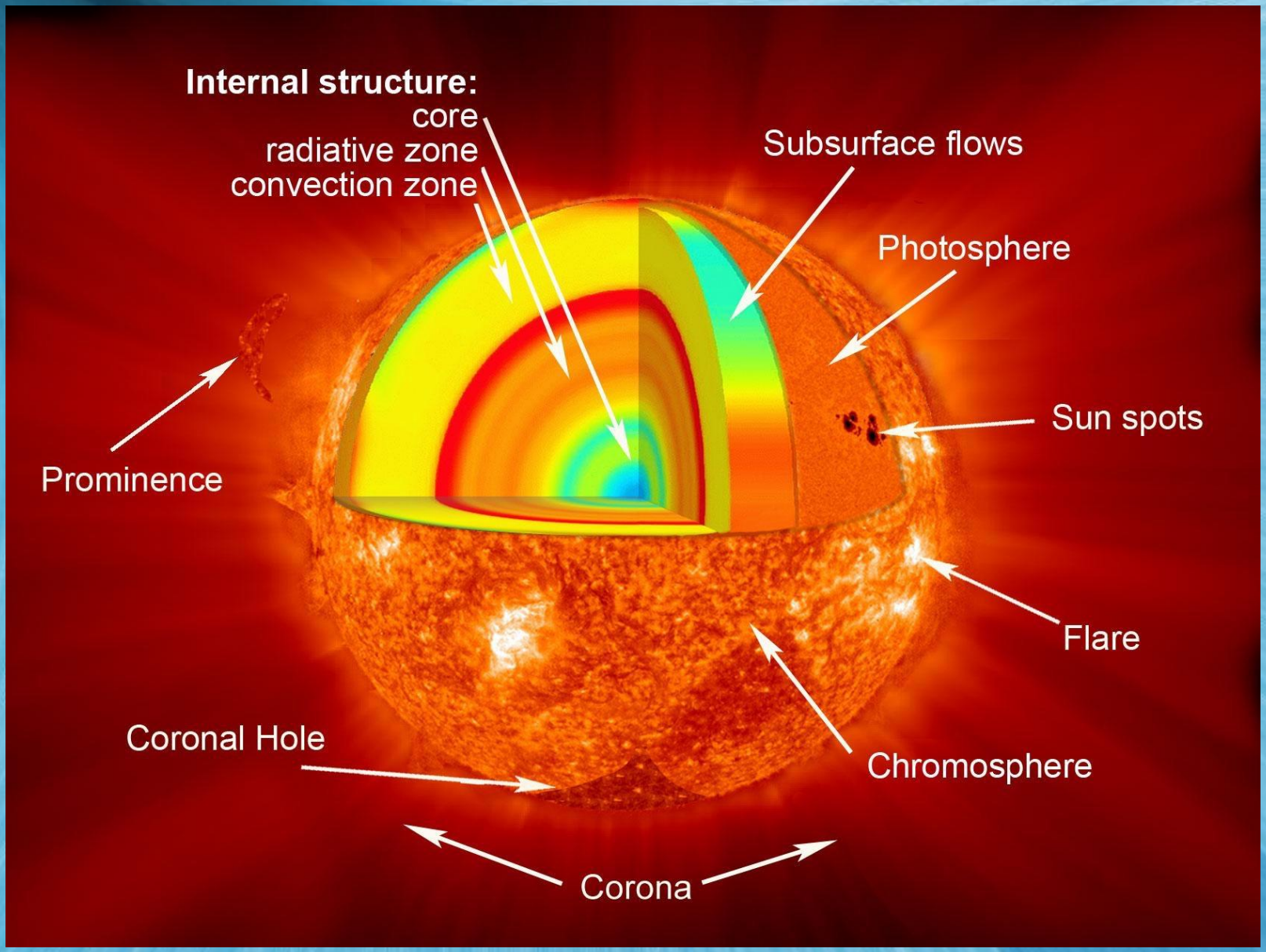

KONA HAWAII

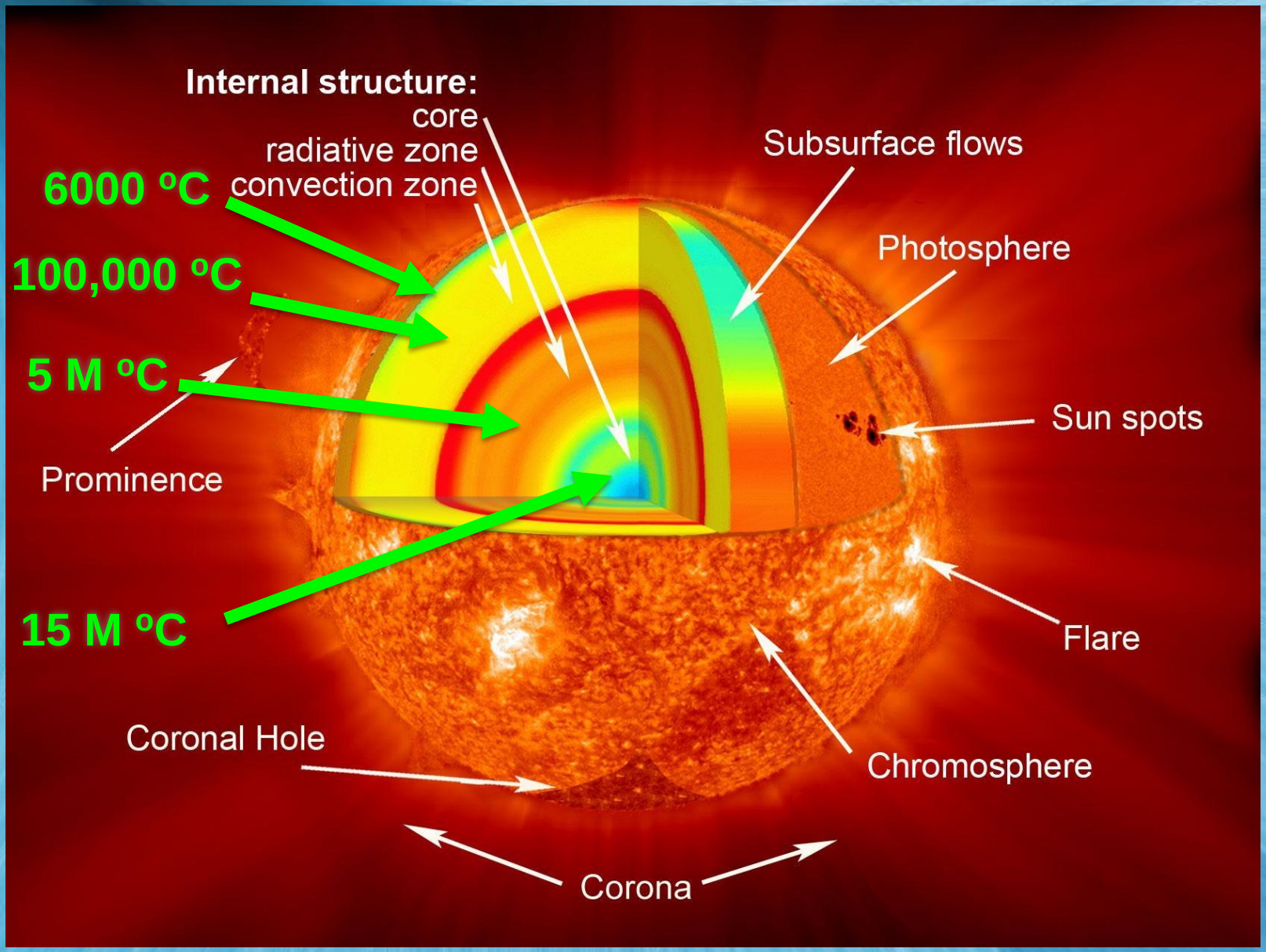



KONA HAWAII



Science of the Sun. A key Problem: The Temperature of the Corona

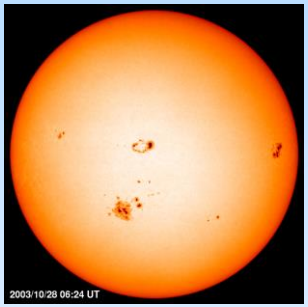

Internal structure:
core
radiative zone
convection zone
Subsurface flows
Photosphere
Sun spots
Prominence
Flare
Coronal Hole
Chromosphere
Corona


Internal structure:
core
radiative zone
convection zone
6000 °C
100,000 °C
5 M °C
15 M °C
Prominence
Subsurface flows
Photosphere
Sun spots
Flare
Chromosphere
Coronal Hole
Corona

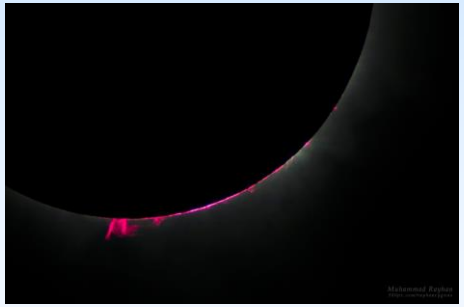
The Solar Atmosphere

The Outer layers (Atmospheres) of the Sun:

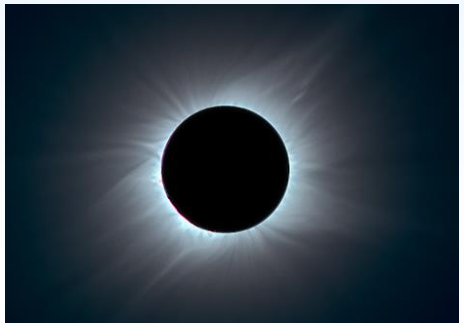
•Photosphere



• Chromosphere



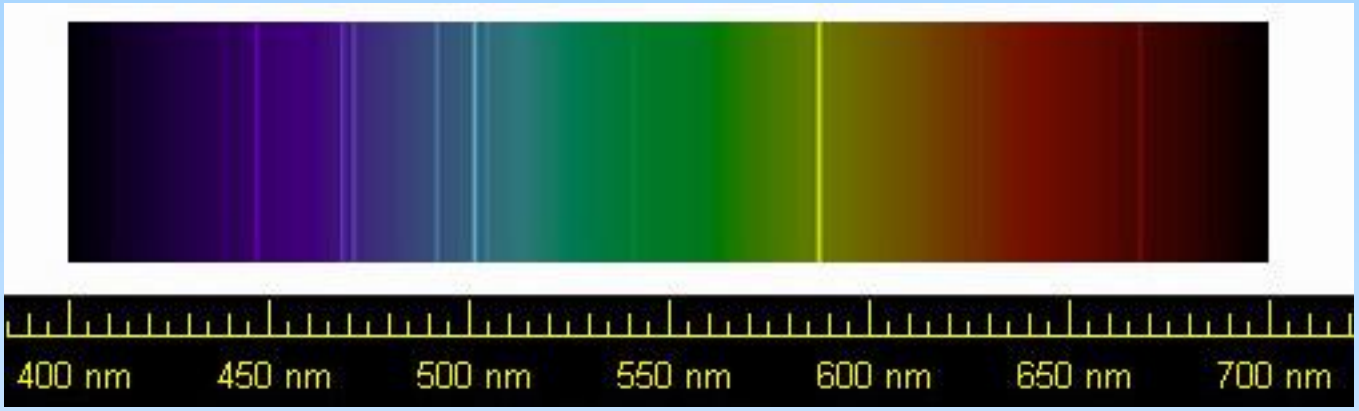
•Corona



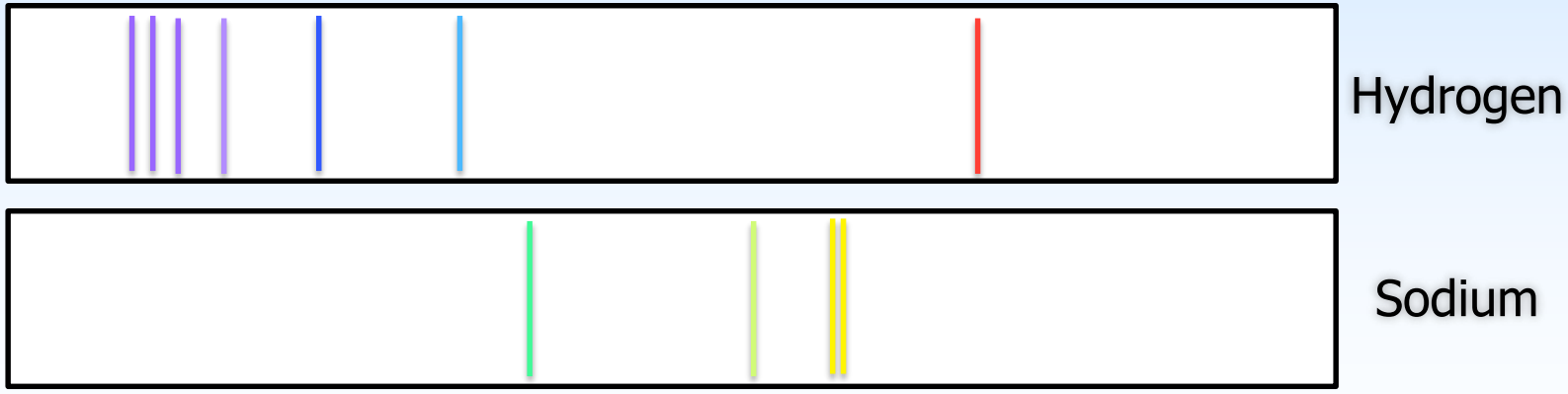
But….

- A “problem” resulted from 1869 eclipse observations of the corona.
- Used a recently developed instrument - the “spectroscope,” to study the corona.

Spectra



- Breaks light into “rainbow” colors, with lines.
- Different elements produce different lines.
- So these lines are like “fingerprints” for elements.



- Hence, spectra can be used to determine the composition of far-away objects, like the corona.

But…

- A “problem” resulted from 1869 eclipse observations of the corona.
- Used a recently developed instrument - the “spectroscope,” to study the corona.

- Found lines that could not be identified!

But…

- A “problem” resulted from 1869 eclipse observations of the corona.
- Used a recently developed instrument - the “spectroscope,” to study the corona.

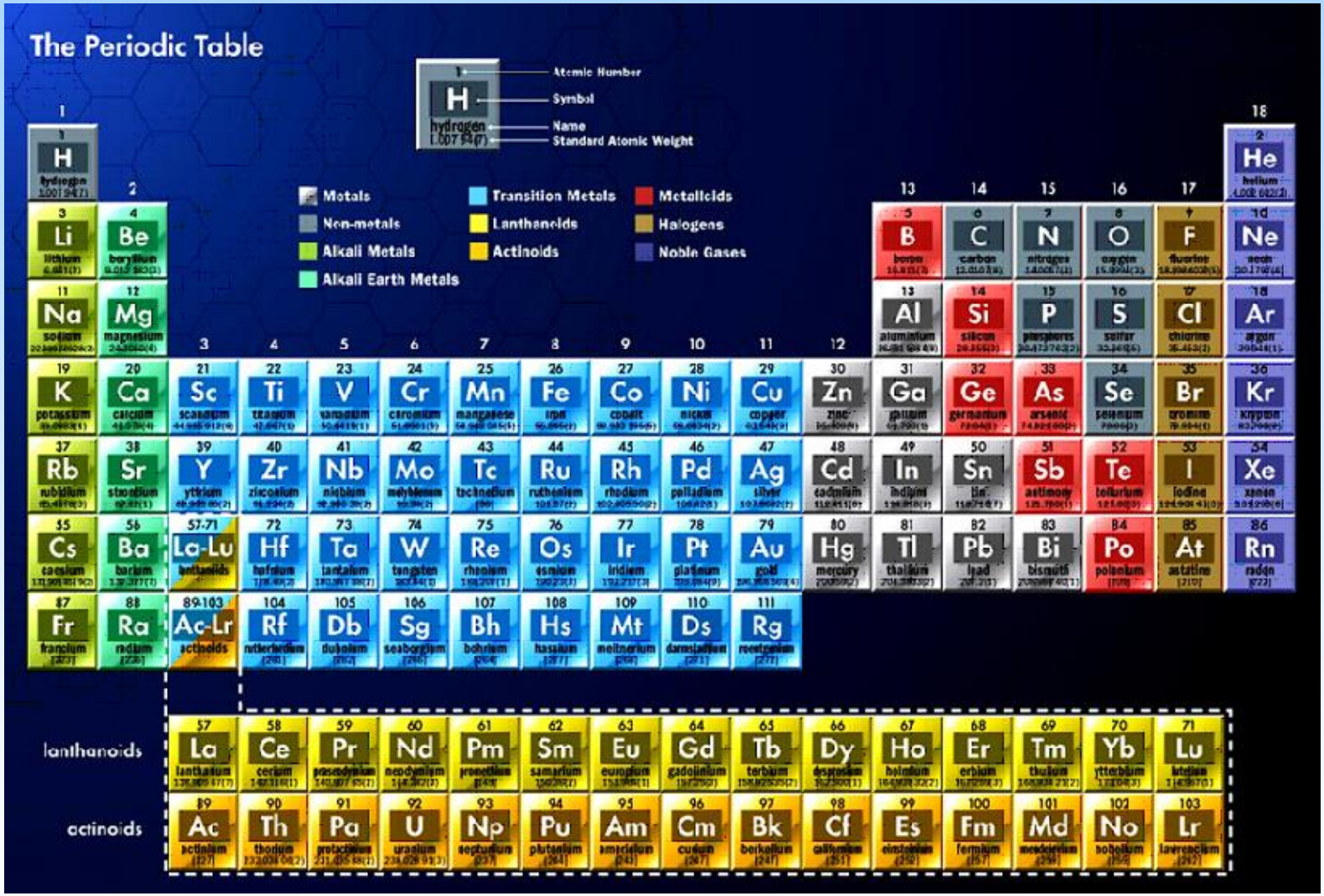
- Found lines that could not be identified!
- Many explanations considered, including a “new” element: *coronium*.

But…

- A “problem” resulted from 1869 eclipse observations of the corona.
- Used a recently developed instrument - the “spectroscope,” to study the corona.

- Found lines that could not be identified!
- Many explanations considered, including a “new” element: *coronium*.

But this didn’t work....


The Periodic Table
Atomic Number
Symbol
Name
Standard Atomic Weight
Metals
Non-metals
Alkali Metals
Alkali Earth Metals
Transition Metals
Lanthanoids
Actinoids
Metalloids
Halogens
Noble Gases
lanthanoids
actinoids

NASA/CXC/SAO

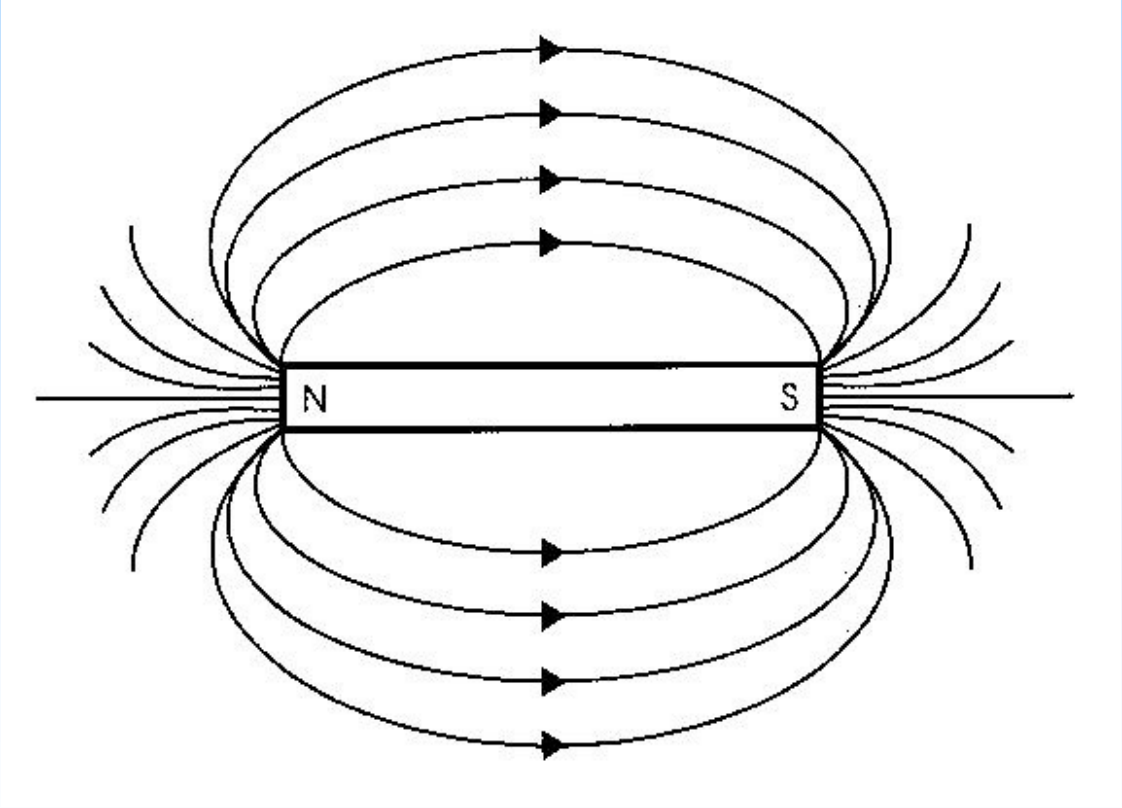
The Corona: Continued...

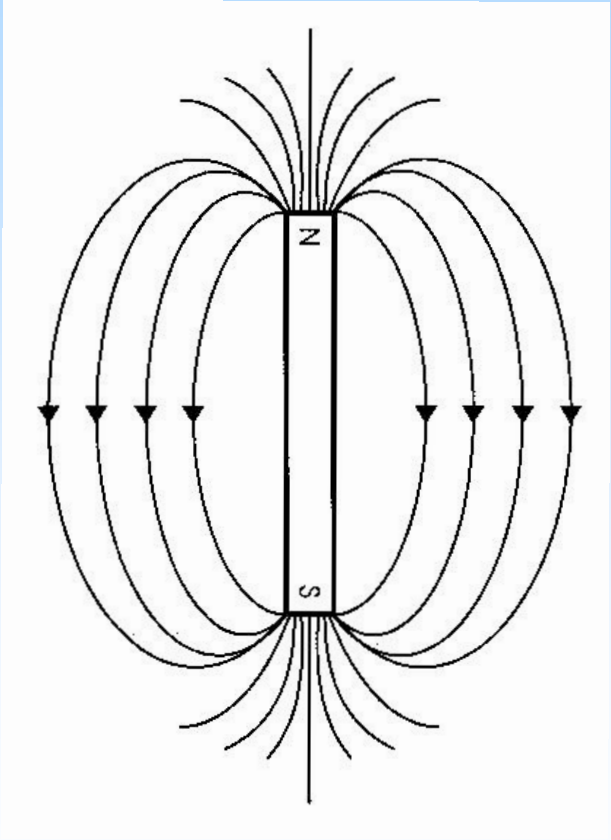
- The mystery spectral lines found to be due to very hot ("highly-ionized") familiar elements ~1940.

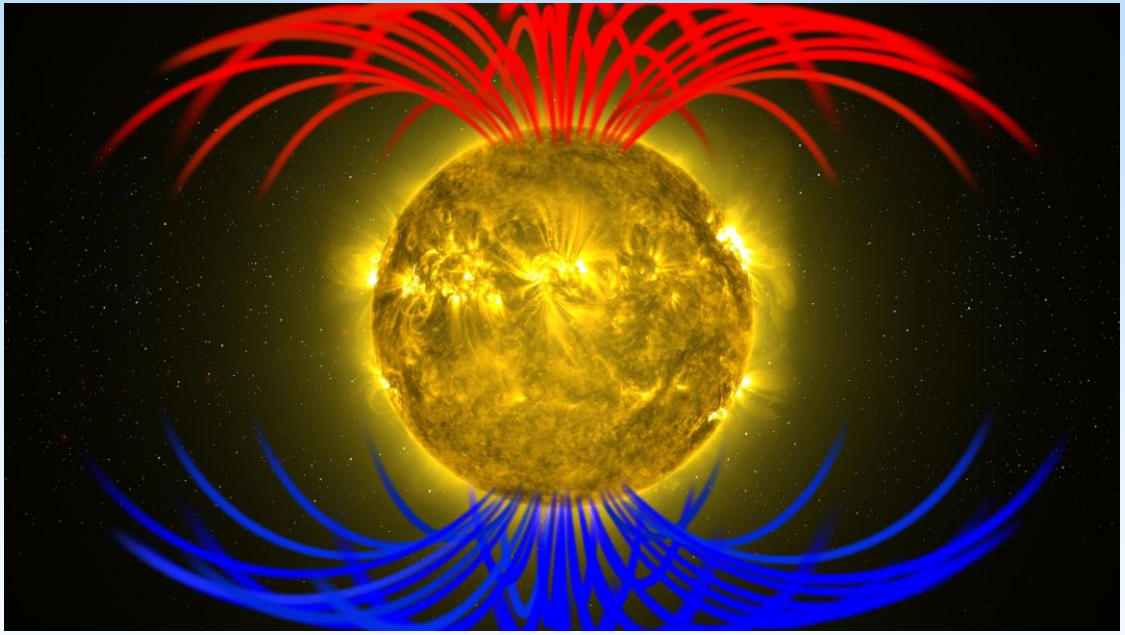
  So this was a sloooow process: 1869 eclipse observations, and 1939~1943 explanation!!

- Structure of the corona: late 1960s and 1970s observations from balloons, Skylab, etc.
- This structure due to the magnetic field.

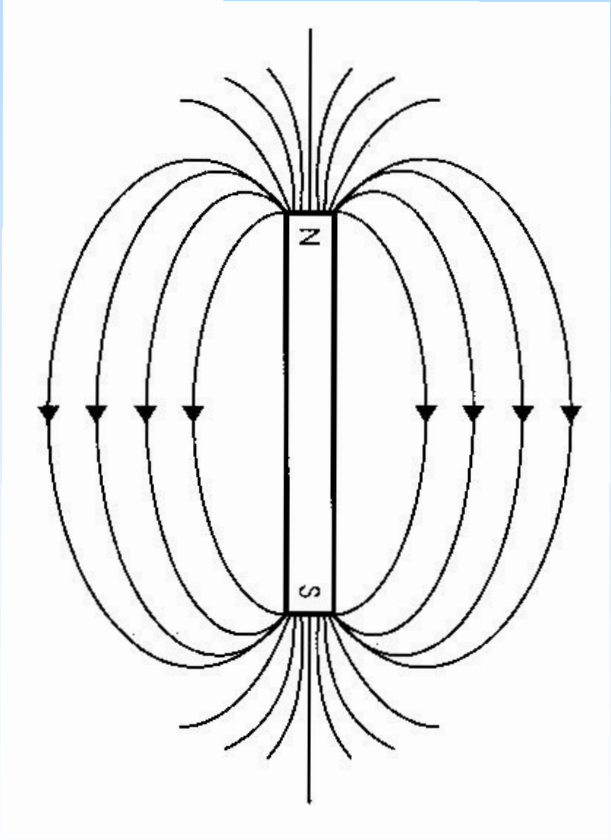
Magnetism is the key to why the corona is hot. (It is also responsible for many of the changing features of the Sun.)

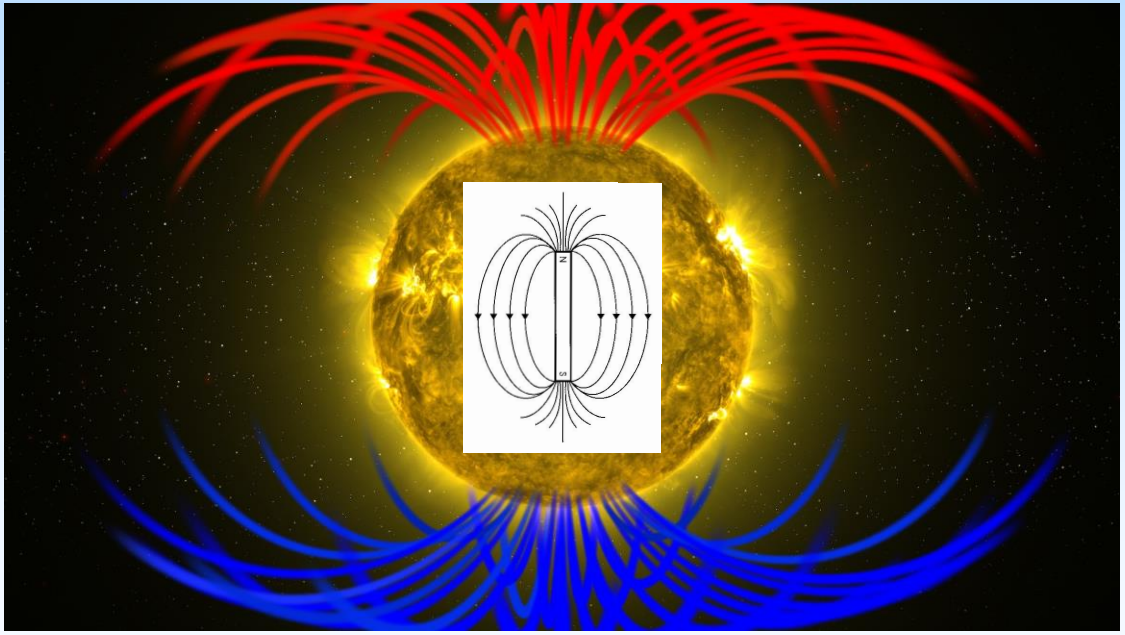



N
S

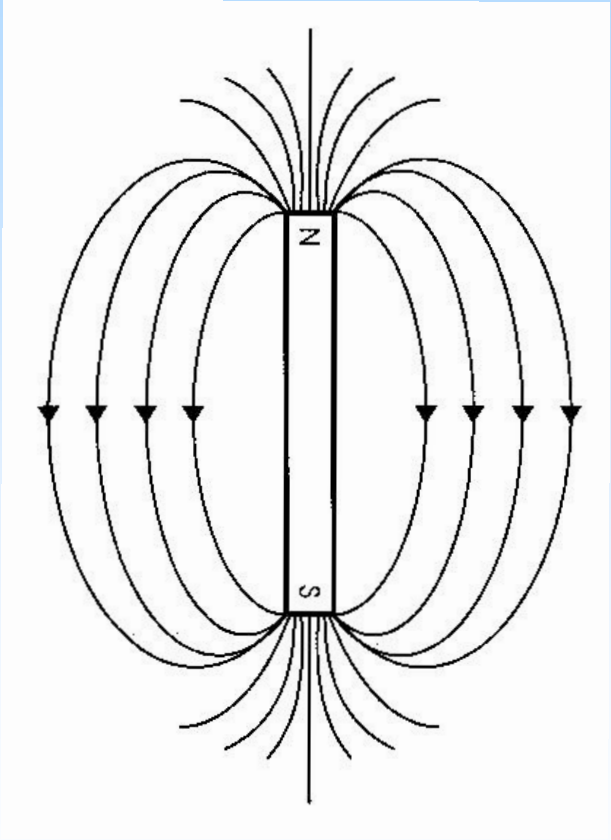


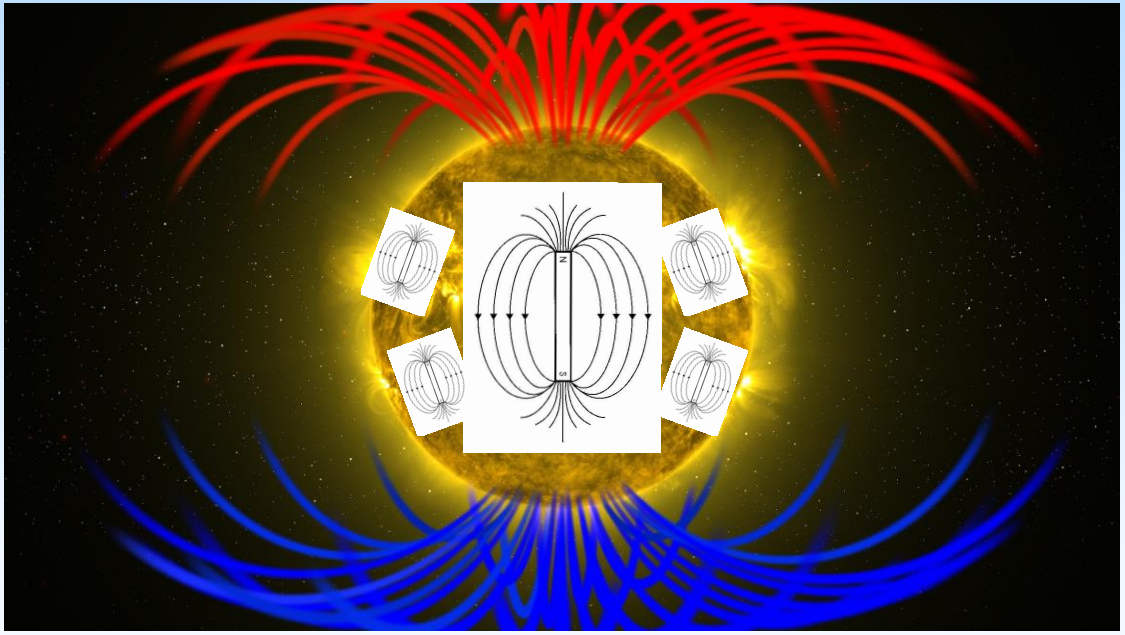
Magnetism is the key to why the corona is hot.

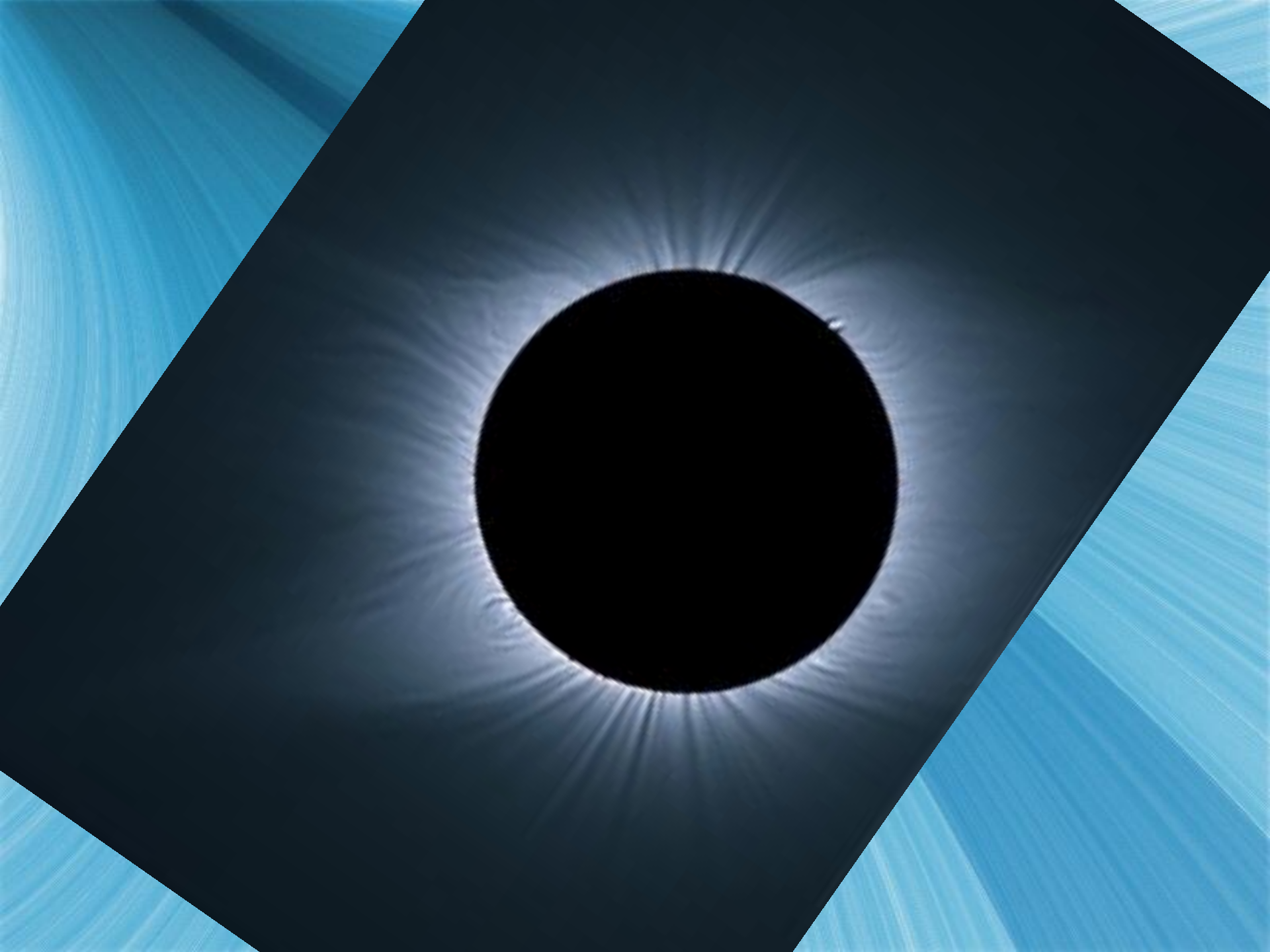




Magnetism is the key to why the corona is hot.







A Key Objective of Solar Physics:

Unravel details of how the magnetic field heats the corona!

- This is one goal (direct or indirect) of many eclipse studies.
- Also, many other stars have hot coronae, and thus understanding the heating of the Sun's corona tells us about other stars too.


of Cape Coast, Ghana

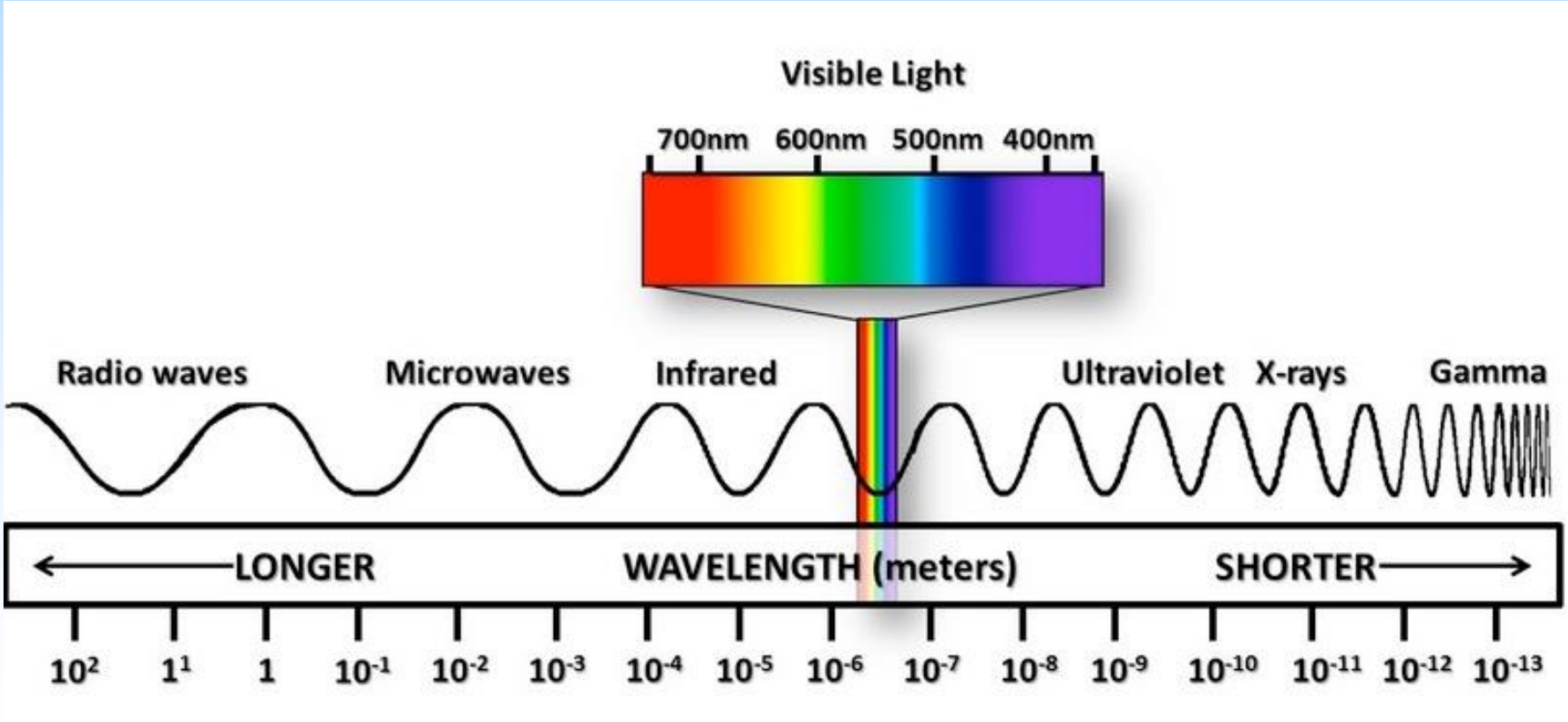

20 May 2012 22:35:02 UT

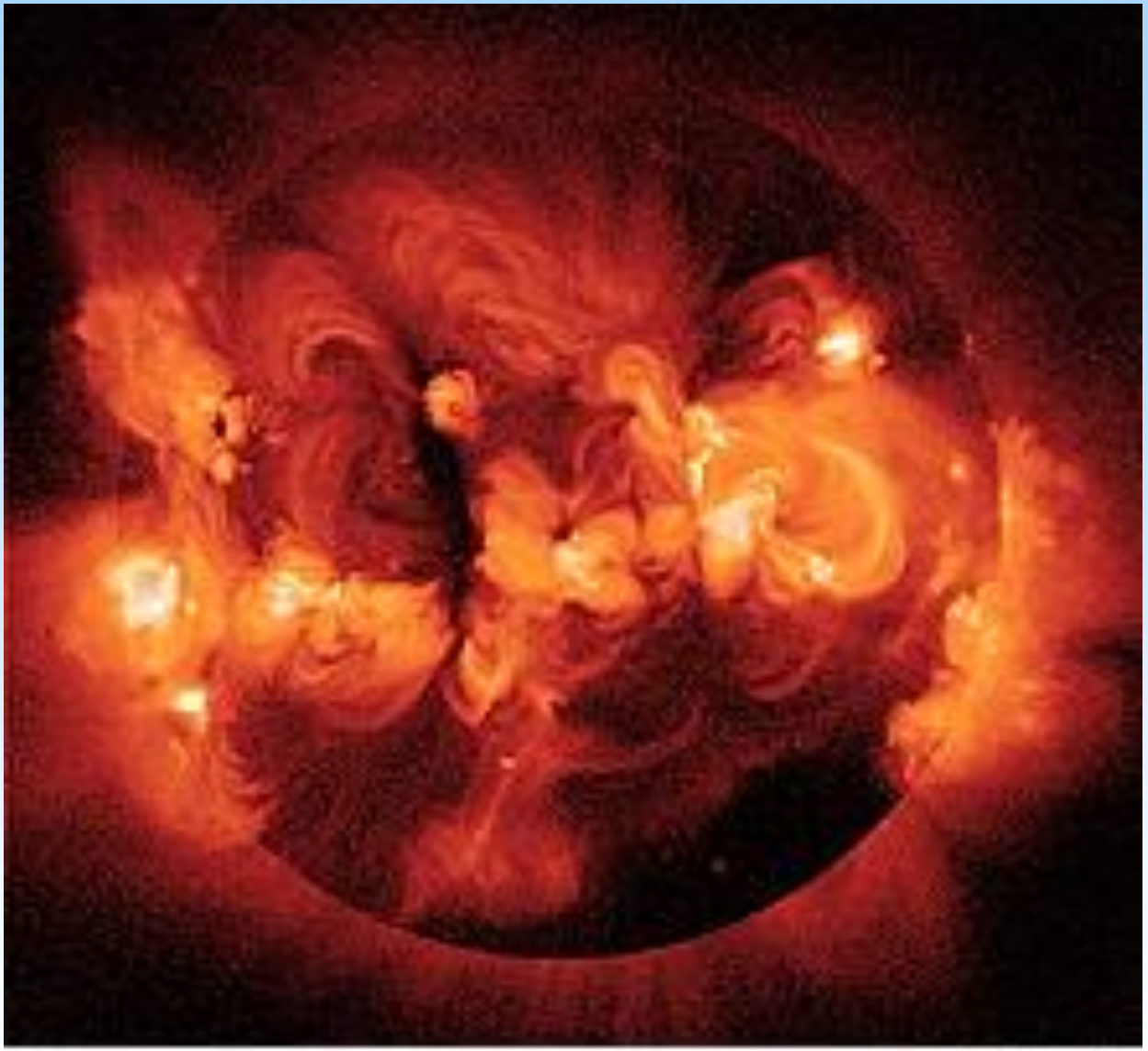

20 May 2012 22:35:22 UT


Volt

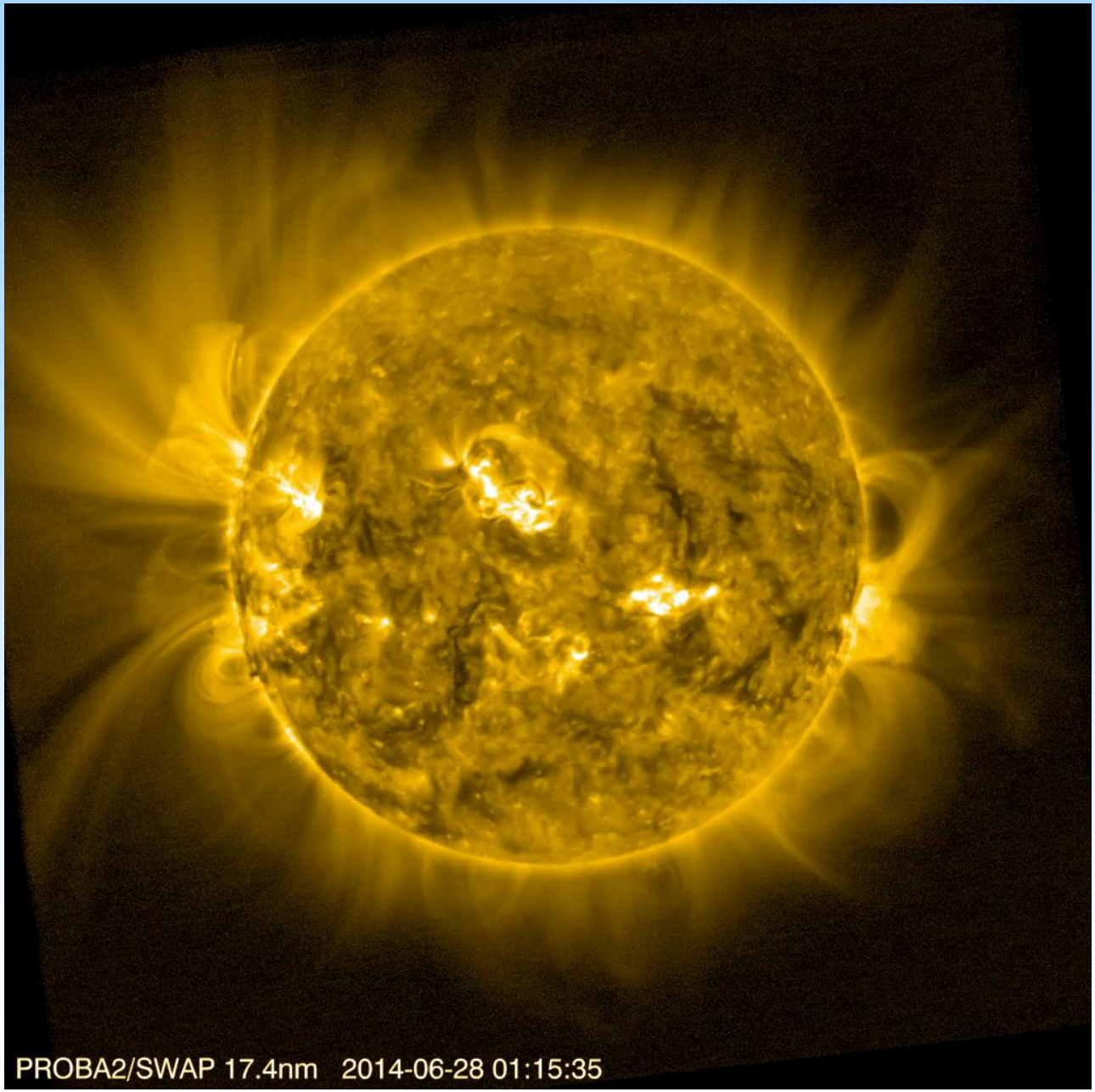

Rotella
OPEL

We have to go to ***space*** to see the Sun's outer atmosphere with regularity.





The Corona from Yohkoh/SXT


PROBA2/SWAP 17.4nm 2014-06-28 01:15:35

The Corona

- Expected to be cool, but found strange spectral lines, first during 1869 eclipse.

- Many explanations considered, including a “new” element: *coronium*.

- **But this didn’t work....**